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MAGSAT DATA INVESTIGATION M-004

E82-10317
NASA-CR-168895

An investigation of Magsat and complementary data emphasizing Precambrian shields and adjacent areas of West Africa and South America.

Quarterly report^{1/} covering activities of the investigation during the period October 1 through December 31, 1981.

(E82-10317) AN INVESTIGATION OF MAGSAT AND
COMPLEMENTARY DATA EMPHASIZING PRECAMBRIAN
SHIELDS AND ADJACENT AREAS OF WEST AFRICA
AND SOUTH AMERICA Quarterly Report, 1 Oct.
- 31 Dec. 1981 (Technicolor Graphic

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^{1/}This report is in "letter format." It has not been formally edited for compliance with U.S. Geological Survey standards or nomenclature.

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LIST OF ATTACHMENTS

- 1. Abstracts for the American Geophysical Union Spring Annual Meeting, May 1981.**
 - A. Part I as approved by USGS review.**
 - B. Part II as approved by USGS review.**

1. Introduction

This quarterly report, on Magsat Data Investigation M-004, covers the period October 1 through December 31, 1981.

2. Problems

No new problems were encountered during the last three months.

3. Accomplishments

- A. The initial description of the Magsat scalar anomaly pattern for Africa has been improved upon, primarily from the initial comparison of Magsat anomalies with models of possible causes of such anomalies. Preliminary vector anomaly maps were received from the Magsat project scientist, and were given an initial analysis, through the modeling emphasized scalar anomalies.
- B. A working edition of the geological map of the world on one sheet has been completed (see Section 3E in the quarterly report of September 30, 1981), on the Mercator projection. Preparation of the map in this projection and in the van der Grinten projection continue.
- C. Initial tectonic correlations of Magsat scalar anomalies have been begun, using the above mentioned map.
- D. Several possible causes for the east-west striping of the Magsat anomaly maps are being studied.

Accomplishments A, B, and C above are in progress. Significant results will be discussed in the next quarterly report. Significant results of D above are discussed below in Section 4.

4. Significant Results

Seven possible causes for the east-west banding on the Magsat anomaly maps are being considered:

- A. The field model that was used for core-crustal separation of geomagnetic anomalies may be inadequate for that purpose. The core-crustal separation was made on the assumption that relatively short anomaly wavelengths are caused exclusively by sources lying above the Curie point isotherm in the lithosphere (disregarding any sources from outside the solid earth). Long anomaly wavelengths were considered to be caused primarily by sources related to a hypothesized geomagnetic dynamo in the core (while recognizing that some long anomaly wavelengths are likely to be caused by regional variations in lithospheric susceptibility and in depth to the Curie isotherm).

As this investigator remembers the procedure for the selection of the wavelength used to separate "long" from "short" wavelengths, a power spectrum (power vs. degree and order) is plotted for Magsat data of degrees/orders through 80 or so. This plot showed a relatively slight decrease in power with increasing degree/order for longer wavelengths, and a more rapid decrease for shorter wavelengths, such that two line segments could be "fit" to short- and long-wavelength portions of the plot. There was some ambiguity over the exact location of the crossover point, where there seemed to be significant contributions from deeper and near-surface sources in the range of 13th-17th degree/order. A 14th degree/order separation was chosen for the production of anomaly maps. However, this ambiguity suggests that the transition may not be so sudden, and that

- anomaly maps with 13th, 15th, 16th, and 17th order separations would be worth investigating for their representation of east-west banding.
- B. Some external-field noise is thought to remain in the available maps. There already has been some discussion of this problem by specialists in this subject.
- C. There may be significant east-west trends of crustal uplift and depression that contribute to the banding of the anomaly maps. For example, the following features have an approximately east-west trend: the Himalayan-Alpine Uplift and the major petroleum rich sedimentary basins that flank this uplift to the south in North Africa and the Persian Gulf, the adjacent and parallel west-east trend of uplift in Africa (Reguibat Shield, the Ahaggar and Tibesti Uplifts and the Arabian Shield), flanked to the south by the Senegal, Taoudeni, Niger, Chad and southern Sudan Basins, flanked to the south by the West African and Central African shields. Major oceanic features that trend predominantly east-west include the Aleutian Island arc, the Greater Antilles, the Indonesian Archipelago, the Scotia Ridge, the Southeast and Southwest Indian Ocean Ridges, the Pacific Antarctica Ridge, and the Challenger Seamount Chain. Though there may be no more east-west trending tectonic features than there are features with other orientations, the Magsat data collection (and anomaly map preparation) process tends to enhance such features.
- D. East-west trends to convection patterns in the mantle may contribute to the anomaly map. Although velocities of convecting materials may be low, the numbers of moving charges (convecting ions) may be large enough to produce a magnetic field measurable by Magsat, and of short enough wavelength to remain in the anomaly map after removal of the

"core field." Convection patterns may also contribute to the patterns of uplift and depression just discussed.

- E. There may be significant east-west bands of crustal materials of similar metamorphic grade. Higher-grades of metamorphism often are considered related to greater magnetite contents of rocks, hence greater bulk susceptibility of the rocks. Unmetamorphosed sediments tend to be virtually nonmagnetic. Convection and related heat-flow patterns are likely to affect regional metamorphic grade.
- F. Variations in the depth of the Curie isotherm might have significant east-west banding. Variations in the thickness of the column above the Curie isotherm affect the bulk magnetization of the lithosphere. The interactions of east-west trends in heat flow, tectonic provinces, rock types, and lithospheric thickness would likely reinforce each other in the east-west banding of variations in depth to the Curie isotherm as well as the variation of magnetic susceptibility above the Curie isotherm. However, the tendencies toward banding might be toward, for example, a deeper Curie isotherm and a lower susceptibility for a sedimentary basin vs. a shallower Curie isotherm and a higher susceptibility for an orogenic belt. Thus, the effect of greater or lesser depth to the isotherm tends to be partially cancelled by lesser or greater (sic) susceptibility in many areas.
- G. The data processing techniques used to overcome the absence of tie lines, and the north-south orbital path of Magsat, would tend to magnify east-west trends. This topic has been discussed by several people at Magsat investigator's meetings.

5. Publications

Some of the copies of my last quarterly report omitted parts of the abstracts "A look at the Magsat anomaly map, emphasizing Africa" Parts I and II. To ensure that complete abstracts are received by each person on the NASA distribution route for Magsat reports, I attach complete abstracts with this report.

The status of publications related to this investigation is unchanged, except for one oral presentation:

Interpretation of the preliminary total-field Magsat anomaly map.

Geological Society of America Annual Meeting, Cincinnati, November 2, 1981
(published in GSA Abstracts With Programs, v. 13, p. 469, 1981).

and for one manuscript currently in USGS and journal review:

A first look at the Magsat scalar anomaly map for Africa, intended for
Geophysical Research Letters.

6. Recommendations

Recommendation A of my last quarterly report was taken care of during this last quarter. Recommendation (request) B, for the provision of the gridded data used to make the anomaly maps, has not been responded to since the initial offer to provide such data last May.

My additional "recommendations" have to do with investigating the possible sources of the east-west banding discussed in Section 4 above.

The first of these problems (A) might be investigated by looking at different degrees/orders for the core-crustal separation. The second problem (B) is better investigated by specialists in the earth's external field. Problems three through six (C-F) might be investigatable by modeling, though these possible causes may be difficult to resolve because of their likely interrelationship.

Problem seven (G) might be alleviated by attempting to find usable data from the ascending (south-to-north) half of each orbital track of MagSat, or by conducting a follow-on mission with a different orbital inclination to the equator. Despite the lower quality of such data due to a lesser constancy of time of measurements, these techniques would help to tie together adjacent tracks with hard data instead of not-so-"hard" processing techniques. A third, more immediately practical, alternative would be to use the tether magnetometer in the space shuttle to provide tie lines (or, at least, to provide some relatively east-west profile data) for investigation.

7. Funds Expended October 1 - December 31, 1981

Salaries

D. A. Hastings, Principal Investigator	220 @ \$13/hr.	\$2,860.00
G. Walvatne, Intern	16 @ \$6/hr.	96.00
Secretarial	8 @ \$4.50/hr.	<u>36.00</u>
		\$2,992.00
Employee benefits (12% of direct labor)		<u>359.04</u>
Labor subtotal		\$3,351.04
Overhead (60% of labor)		<u>2,010.62</u>
Labor total		\$5,361.66

Materials

1. Custom laboratory interim photographic products	\$1,490.00
2. Landsat imagery (1 computer compatible tape @ \$12.00)	<u>200.00</u>
	\$1,690.00

Travel

Geological Society of America, paper presentation,	
consultation with specialists attending the meeting,	
November 1981	\$ 764.56

Other

1. EROS Data Center Data Analysis Laboratory

10 hours @ \$125/hr.

\$1,250.00

2. Office Supplies

10.00

\$1,260.00

Subtotal

\$9,076.22

General and Administrative (13.3%)

1,207.14

Grand Total

\$10,283.36

8. Data Utility

I have no new comments on this topic at this time.

ATTACHMENT 1A

A LOOK AT THE PRELIMINARY MAGSAT ANOMALY MAP, EMPHASIZING AFRICA:

I. ARE THE ANOMALIES SIGNIFICANT?

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ABSTRACT

The preliminary scalar anomaly map from the magnetic field satellite (Magsat) data closely resembles the map from Polar Orbiting Geophysical Observatory (POGO) data, although the Magsat anomaly map shows considerably greater detail. Highlights over the African Continent include the resolution of the West African Craton into its nucleus, the Taoudenni Basin-Senegal Basin, and the transition from the Reguibat Shield to the Tindouf Basin; the grouping together of the Ahaggar and Tibesti Plateaus as well as the depiction of the partial breaching of this grouping by the Murzuk Basin; the sedimentary basins between the Atlas Mountains and the Ahaggar; the triple "bulls-eyes" apparently caused by the Benue Trough, the Congo Basin, and the band of high-grade Archaean metamorphic shield rocks running from the Central African Republic to Cameroon and Gabon (commonly referred to as the "Bangui anomaly"); the coastal basin of Mozambique; and the Karroo Basin. Offshore features represented on the anomaly map include the Agulhas Plateau southeast of the Karroo Basin, the Indian Ocean ridge system, the near-coastal (east-west trending) segment of the Walvis Ridge, and (to a lesser extent) other tectonic features of the Atlantic Ocean. Indeed, almost all of the major tectonic features of Africa on a scale resolvable by the Magsat satellite appear clearly

^{1/} Work performed under U.S. Geological Survey Contract No. 14-08-001-164390.

ATTACHMENT 1A (cont.)

on the map. Notable exceptions are the East African Rift system and the Atlas Mountains. Despite some uncertainties about apparent banding in the preliminary anomaly map, the scalar anomaly patterns over Africa appear to represent major tectonic features on the continent.

A LOOK AT THE PRELIMINARY MAGSAT ANOMALY MAP, EMPHASIZING AFRICA:

II. AN INITIAL DISCUSSION

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ABSTRACT

IN Africa, as elsewhere, the preliminary Magsat anomaly map tends to emphasize east-west trending tectonic features and to subdue north-south trending features. For example, the north-south East African Rift system is not depicted by closed anomalies other than a weak anomaly at the northeastern corner of the Mediterranean Sea which corresponds to the northern end of the system. On the other hand, the east-west Karroo Basin is well depicted by a negative anomaly. This effect is expected, as the greatest net magnetization of crustal bodies occurs along the sides of east-west trending bodies, and at the ends of north-south trending bodies. Another possible contributing factor to the emphasis on east-west trending features might be the lack of east-west tie lines in the north-south orbit of the satellite, coupled with filtering of the data only along-track.

In the northern part of the map for Africa, uplifted Archaean-Proterozoic shields tend to be associated with negative residual Magsat anomalies. Sedimentary basins tend to be associated with positive anomalies. The reverse is generally true south of the equator. Exceptions to these associations are the Reguibat Shield-Tindouf Basin area, which is not fully resolved on the anomaly map, and the horn of Africa where a negative anomaly covers the onshore and offshore

^{1/}Work performed under U.S. Geological Survey Contract No. 14-08-001-16439.

Somali Basin. One intriguing, and as yet unexplained, observation is that the reversal in polarity of magnetic anomalies for given types of features occurs at about latitude 10° S. (Cabinda to central Madagascar), whereas the magnetic equator lies at about latitude 10° N. across Africa.

The main sources of Magsat anomalies appear to be older Precambrian shields, and sedimentary basins of various ages. The younger Precambrian (pan-African) "mobile belts" tend not to produce marked Magsat anomalies.

Further interpretation awaits refinement of the Magsat anomaly map, which is now underway.